Handbook for Using AFIT, the Alternative Fuels Investigation Tool

Companion to

ACRP Report 46

AIRPORT COOPERATIVE RESEARCH PROGRAM **2011**

CONTENTS

CHAPTER 1

Introduction

This handbook is designed to help airports, fuel suppliers, and other interested parties evaluate the costs and benefits of using an alternative jet fuel at an airport. The alternative fuels considered are an ultralow sulfur (ULS) jet fuel and synthetic paraffinic kerosenes (SPKs). SPKs include Fischer-Tropsch fuels and hydroprocessed renewable jet fuel created from feedstocks such as algae and palm oils. The handbook is a guide to using the Alternative Fuels Investigation Tool (AFIT) and interpreting the results. More detailed information about using alternative fuels at an airport can be found in the technical report for ACRP Project 02-07, under the same cover as this handbook and available on the TRB website (www.trb.org) by searching "ACRP Report 46." The report provides additional detail on alternative fuels transport and use, emission impacts, equipment modification considerations, and the use of AFIT. AFIT has been developed to estimate costs associated with the introduction of an alternative fuel and associated emissions reductions. AFIT does not provide a cost–benefit metric. Deciding whether to introduce an alternative fuel to a specific airport is a complex decision and is beyond the scope of this research and the AFIT software tool. It must also be noted that AFIT, in its present configuration, is only for analyzing alternative jet and ground support equipment (GSE) fuels and is not intended for a total fuels analysis including natural gas, compressed air, biodiesel, or electric power.

1.1 Why Should an Airport Consider Using an Alternative Jet Fuel?

Fuel prices and price volatility, local air quality, and greenhouse gas (GHG) emissions are among the issues airports face as a result of the fuel consumed by airports and airlines. The cost of fuel is a significant budget item for airports and especially airlines, and wide swings in the price of fuel complicate financial and operational planning. Alternative fuels are now recognized as one option for expanding total fuel supply, reducing reliance on a single resource, and potentially stabilizing fuel prices.

Emissions from fuel combustion are an airport's primary contribution to air pollution. These emissions are expected to increase, following the growth in fuel use as airports expand capacity to meet increasing demand for air travel, unless steps are taken to reduce them. Airports require new strategies for mitigating these impacts on their communities, and one such strategy is to use alternative fuels in place of conventional fuels.

Global climate change is now widely viewed as a significant, serious environmental threat, and aviation sources have limited opportunities for reducing their GHG emissions. Alternative fuels represent one potential strategy for airports to address their GHG emissions compared to other industries and reduce their carbon footprints.

Using alternative jet fuel in place of conventional jet fuel (Jet A) offers a variety of environmental and operational benefits. A "drop-in" alternative jet fuel—that is, one that could be accommodated at an airport with little or no modification—would allow an airport to readily make such a change. Drop-in, low-sulfur alternatives to Jet A can also be used to fuel diesel powered equipment. This offers the possibility that GSE as well as aircraft could use the same fuel, simplifying fuel distribution and reducing the amount of fuel handling equipment.

Alternative jet fuel may soon be available to airports. ULS jet fuel and SPK are the leading candidates for near-term use. The purpose of this handbook and the accompanying AFIT tool is to assist airport managers in deciding whether to use alternative fuels by quantifying the costs and benefits of using them.

1.2 What Are the Benefits of Using an Alternative Jet Fuel?

Alternative jet fuels have the potential to

1. Stabilize or lower total fuel costs,
2. Increase the planning flexibility airports need to reduce emissions,
3. Diversify supply options, and

4. Reduce the amount of equipment needed to distribute fuel on the airport.

Also, since SPK fuels can be produced from a wide variety of non-petroleum feedstocks (e.g., coal, natural gas, biomass, renewable oils, and waste products), they may be produced at a cost advantage compared to Jet A. SPK fuel also reduces particulate matter (PM) and sulfur oxide (SO_x) emissions.

Using alternative jet fuel can also reduce pollutant emissions that impair air quality as well as those considered GHG emissions. Reduced emissions can potentially reduce any known health impacts of airport operations on employees and adjacent communities. However, when considering GHG emission impacts, the feedstock and fuel production process must be considered to account for life-cycle emissions.

A significant share of GSE operating at most airports uses diesel fuel. Since jet fuel is similar to diesel, GSE can also use alternative jet fuel. Fueling GSE with ULS or SPK jet fuel would achieve many of these benefits and reduce emissions and fuel handling costs.

1.3 Are There Regulatory Considerations Involved?

The American Society of Testing and Materials (ASTM) determines the requirements that jet fuel must meet for physical properties, chemical content, contaminant limits, and overall performance requirements. ASTM 1655D is the current fuel specification and enumerates all of the jet fuel requirements. ASTM is currently assessing whether SPK fuels should be certified for commercial aircraft use. It is anticipated that ASTM will certify SPK fuels in up to a 50% blend with conventional fuels in 2011. The Commercial Aviation Alternative Fuels Initiative (CAAFI) has a goal of obtaining ASTM certification for a 100% SPK fuel by 2013. SPK fuels are considered to be drop-in replacement fuels since they could be handled, distributed, and used at airports with a minimum of modification to existing equipment. Only drop-in fuels are considered in this handbook.

Sulfur in fuel results in emissions of both SO_x and PM, and removing sulfur from fuels reduces fuel combustion emissions. For this reason, the U.S. Environmental Protection Agency (U.S. EPA) sets maximum limits on the sulfur content of fuels. The EPA has already reduced the allowable sulfur content of diesel fuel for on-road vehicles and has regulations in place to phase in restrictions on the sulfur content of diesel for off-road vehicles, including GSE. Removing sulfur from Jet A to produce a ULS jet fuel will significantly reduce PM and SO_x emissions from aircraft as well as GSE using that fuel. Note that conventional Jet A does not have stringent sulfur limits and cannot be used in GSE since the fuel would exceed the allowable sulfur content for off-road vehicles.

SPK fuel also reduces PM and SO_x emissions and potentially improves fuel economy due to its higher energy content per unit weight. While ULS jet fuel comes from conventional petroleum, SPK fuels can come from a variety of sources. When considering GHG emission impacts, the feedstock and fuel production process must be considered.

1.4 What Are the Costs of Using an Alternative Jet Fuel?

Alternative jet fuels, just as Jet A, must be transported from a fuel production facility to an airport via multiple transportation links. A likely sequence includes transportation from a production plant to a storage facility, where the fuel is accumulated until sufficient quantities are ready to be shipped a considerable distance via barge, marine tanker, or pipeline. The fuel would likely be received at another tank farm from which it would be sent to the airport via truck or rail.

Somewhere along the way it is necessary to blend SPK alternative fuel with conventional jet fuel to produce a blended fuel acceptable to airlines, ASTM, and airports. This could occur at the fuel production facility, one of the storage facilities, or the airport. Once on the airport, the fuel can be distributed using existing tanks, pumps, and hydrants or trucks. ULS jet fuel or blended alternative fuel with sufficiently low sulfur content can also be used in GSE and other diesel equipment. This would allow the airport to remove existing diesel storage and handling equipment, reducing maintenance and fuel handling costs. Costs related to transportation links, equipment modification requirement costs, and fuel costs are captured in AFIT to determine the cost of using an alternative jet fuel at an airport.

At present, diesel fuel that is used in GSE is taxed by state and local authorities. Any alternative fuel that is used to replace diesel would also be subject to this tax. This change is not captured in the AFIT tool since there should be zero cost difference.

1.5 Who Should Use the Handbook?

This handbook describes the use of AFIT, an automated computational methodology for conducting a cost–benefit analysis. The analysis is intended to help airports and others consider whether to use an alternative jet fuel. It is most useful as a screening tool to help the user identify cost considerations and develop an initial estimate of environmental benefits.

The handbook guides the AFIT user in evaluating the costs of acquiring, transporting, distributing, and using an alternative jet fuel as well as evaluating environmental benefits. It was designed with airports in mind but would be useful for anyone interested in alternative fuel use at airports. For example, an alternative jet fuel producer can use AFIT to develop a marketing approach for working with an airport. A fuel service company could use it to better understand the process and costs involved in acquiring and transporting an alternative jet fuel from a production site to an airport. An environmental analyst could use it to evaluate the degree to which emissions could be mitigated through the use of alternative jet fuel.

1.6 What Is Required for Using AFIT?

AFIT is a 32-bit Windows native application that runs on Microsoft Windows 2000, XP, Vista, or 7.

AFIT uses relatively simple, readily available data to quantify alternative fuel transportation and equipment modification costs. Fuel costs are determined using inputs related to fuel use quantity, transportation sequence, and handling requirements. To determine environmental benefits, AFIT requires a baseline emissions inventory from FAA's Emissions and Dispersion Modeling System (EDMS) as an input.

AFIT produces a report enumerating the costs and potential savings that can come from using alternative jet fuel and summarizes changes to an airport's emissions inventory. Additional details on using AFIT are presented in the following sections of the handbook.

1.7 What Data Will Be Needed to Use AFIT?

The user will need to be familiar with the airport's current fuel usage, either annually or monthly, for both diesel and Jet A. The user will also need to be familiar with price per gallon paid for each. AFIT has default fuel price settings based on typical prices paid throughout the United States and averaged. Appendix B in this handbook also lists several sources for fuel information. The user also has to determine whether the study is for alternative fuels to be run through existing equipment or whether the alternative fuel is part of a significant expansion to the airport where new construction will be required. The user also must select the type of alternative fuel to be considered in the study and should be familiar with types of fuel available and costs at the producer.

Familiarity with the current costs of fuel delivery will also be helpful. Storage, flowage, throughput, and other fuel handling per-gallon costs of existing fuels and those expected for the alternative fuel are also helpful. AFIT supplies default costs, but they are averaged from airports across the United States. Knowledge of the current GSE fleet and suppliers of parts and service will be needed to estimate change-out costs. Access to past construction estimates and project documents or current contact with construction companies and fuel supply vendors will improve the accuracy of estimates. As the alternative fuel replaces diesel fuels, removal and decommission costs of the diesel system will also need to be estimated.

If emissions analysis will be conducted, access to the latest EDMS study will be needed. EDMS details appear below.

1.8 What Is EDMS?

EDMS is a combined emissions and dispersion model for assessing air quality at civilian airports and military air bases. The model was developed by the Federal Aviation Administration (FAA) in cooperation with the United States Air Force (USAF). The model is used to produce an inventory of emissions generated by sources on and around the airport or air base and to calculate pollutant concentrations in these environments. More information regarding the current version of EDMS (5.1.2) (including the User Manual and ordering information) can be found in FAA's EDMS website (http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model).

1.9 What Is an EDMS Study?

An EDMS study is an airport emissions inventory computed from user inputs by the EDMS software. An EDMS study can contain multiple scenarios and multiple airports and can span multiple years. For each scenario-airport-year combination, the user can define operations for aircraft, GSE, roadway vehicles, parking facilities, stationary sources, and training fires.

1.10 Does AFIT Contain EDMS and Why Is EDMS Needed?

- AFIT does not contain EDMS.
- AFIT analyzes aircraft and GSE information from an existing EDMS study to estimate a baseline emissions inventory.
- The baseline inventory is adjusted by AFIT and is not intended to match the EDMS inventory.
- It then computes the airport emissions as though an alternative fuel was used at the airport. AFIT is designed to evaluate the costs and benefits of using an alternative jet fuel at a single airport.
- Therefore, only one scenario-airport-year EDMS set of inputs can be analyzed at a time by AFIT.

1.11 Can an Old EDMS Study Be Used as an AFIT input?

Any study created using EDMS version 5.0 or later can be used regardless of the year modeled. If the EDMS study contains multiple scenarios, airports, or years, AFIT will import emissions from the first scenario-airport-year combination.

CHAPTER 2

Conducting a Cost–Benefit Analysis of Alternative Jet Fuel Use

2.1 Cost–Benefit Analysis Assessment Process

Making provision for or switching entirely over to an alternative jet fuel carries with it a variety of costs. Modifications to equipment and airport infrastructure and their corresponding cost estimates should all be included in the cost–benefit comparison analysis. It is also possible that adopting a single fuel source for aircraft and diesel engine GSE will reduce cost where a new airfield or significant expansion of an existing airfield is involved.

AFIT is a software cost and benefit calculation tool and is offered to assist users with the complex calculations required to determine costs and emissions reductions. Users can either provide custom inputs based on their own circumstances and requirements or opt for default input values provided in AFIT. Research into typical costs for delivery, storage, blending, filtering, and on-site equipment upgrades and replacements produced a range of expected values likely in the switch to an alternative fuel. These default values are offered as guides to the user. AFIT displays conversion costs both in terms of per-gallon of fuel consumed and total cost.

AFIT consists of five tabs, or information areas:

1. General setup information—monthly fuel usage, fuel price, and airport fuel conversion type.
2. Fuel economics—fuel transport, storage, and blending information.
3. Equipment costs—GSE part replacements for filters, seals, and fuel pumps (which may be required); avoided capital investment cost of a diesel fueling station in the case of airport expansion or new facility construction.
4. Emissions—emissions affecting air quality as well as life-cycle greenhouse gas emissions; both are provided for the current fuel and the alternative fuel.
5. Report—fuel and equipment cost and emissions comparison results.

AFIT displays baseline and alternative fuel cost and emission estimates and the relative change between them at the top of each tab, keeping a rolling update as users enter values in the lower portions of each tab. The user is able to determine the relative cost changes and compare them to the relative emission reduction benefit for use in deciding the merits of a switch to an alternative fuel. AFIT does not answer the question of whether alternative fuel use is the right decision. It simply compares the costs and emissions with and without a drop-in alternative fuel.

AFIT is designed to analyze drop-in fuel use in either existing fuel delivery systems, where no additional or new fuel delivery upgrades are planned, or in cases where a new airfield or significant expansion of the existing fuel delivery system is planned.

2.2 Using AFIT

AFIT is available on the CD enclosed with this handbook. AFIT can be run to conduct a complete cost and emission reduction benefit assessment. To estimate costs, the user needs information on current fuel usage, fuel prices, airport fueling infrastructure, and the ground support equipment that would use the fuel. To estimate emissions reductions, the user needs to have an EDMS run with an emissions inventory. If an EDMS run is not available, the tool can still be used to estimate the change in costs.

Download and Launch the Software

Copy the AFIT Installer file folder to your computer. Double click the installer to install AFIT on your computer. Follow the instructions, clicking "Next" to complete the installation. Find the folder titled "AFIT" on your computer's start menu (typically under "All Programs") and launch the application.

Upon opening AFIT the user is presented with the “Setup” tab and can see the other four tabs, or sections of the analysis tool, that group input and output of similar type. The “Setup” tab collects basic information about the user’s monthly fuel consumption, price paid, and fuel scenario.

Setup

The “Setup” tab, Figure 1, allows the user to select the type of analysis: fuel costs, equipment costs, and/or emissions (selecting or not selecting these fields gives or restricts the user’s access to the associated parts of AFIT), the alternative fuel composition that will be analyzed, and where it will be used. The alternative fuel composition options are (1) JET A + SPK, (2) ULSJ, and (3) ULSJ + SPK. Due to ULS standards, the Jet A + SPK fuel composition cannot be used in the GSE and can only be used in aircraft. The user selects the blend percentage for the alternative fuel (50% is the maximum blend percentage for alternative fuel in this version of AFIT).

In this tab, the user also inputs monthly fuel-use information for Jet A and diesel in terms of consumption and price.

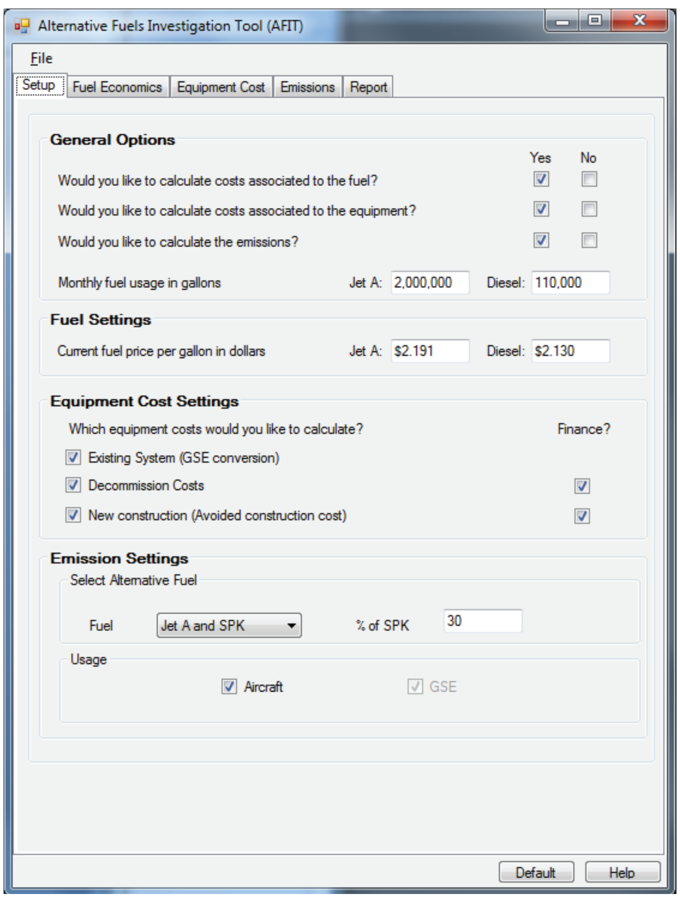

Figure 1. “Setup” tab.

Enter whole gallons (decimal places are not critical) for the average fuel consumed in a month. If consumption statistics are listed in barrels, the conversion factor for barrels to gallons is 42 gallons/barrel. (Multiply barrels used by 42 to get gallons used.) These inputs are only used for estimating monetary costs; they are not used for the emissions calculations, which will be discussed below. Enter the current price for Jet A and diesel fuel. As broad price swings can occur over the course of a year, selecting a yearly average or another suitable price approximation representative of typical values is suggested. Several sources exist to help the user with fuel price estimates. Appendix B contains a list of sources where the AFIT user can find current and historical fuel price information.

Default values exist in AFIT if the user does not know the input values for the “Setup” tab. Clicking the “Default” button in the lower right corner will import default values. The analyst must provide airport fuel-consumption statistics; otherwise, a default value of zero will be used. Fuel prices for Jet A and diesel reflect representative values of the fall of 2008; updated values can be found on the EIA website at http://www.eia.doe.gov/oil_gas/petroleum/info_glance/petroleum.html.

Three “Equipment Cost Settings” options are presented on the “Setup” tab. These allow the user to determine whether separate (possibly existing) diesel fuel facilities are to be used or whether fuel supplied to GSE and other diesel equipment will use the jet fuel supply system. These fields activate other functions and calculations in AFIT to help guide the user through the analysis process.

- Click the “Existing System” box if the alternative fuel will be delivered to and through the existing fueling system only. After clicking, a check mark should appear. No additional fuel delivery equipment will be purchased or installed.
- Click the “New Construction” box if new diesel fueling and delivery equipment will be constructed and installed. After clicking, a check mark should appear. Typically this includes fueling pumps, storage tanks, fueling-island concrete, piping, valves, and so on.
- Click the “Decommission Cost” box if diesel fueling equipment will be removed or taken out of service.

If the user supplies no information, upon clicking to navigate to another tab, the software will ask the user if default values should be used. If “no” is selected, other fields are left open for user input values. Selecting “yes” will insert appropriate fields with default values. There is also a “Finance” option. Since decommissioning costs and new construction can be quite expensive, the ability to calculate typical financing costs over a period of payments is enabled by clicking the finance check box.

Within the "Setup" tab, the user also selects the fuel composition being examined. Within the "Alternative Fuel Composition" box, the user selects the primary fuel—ULS Jet or SPK. The blend percentage determines the amount of alternative fuel that is being used—values between 0% and 50% are available. The user has two check boxes to select the fuel composition that is being blended with the alternative. The user should select "Jet A" if he or she is interested in examining a blend of SPK fuel with conventional jet fuel. The user should select ULSJ if the user is interested in examining either ULS jet fuel or in examining a blend of SPK fuel with ULS jet fuel. Because conventional jet fuel is not allowed for use in GSE, the AFIT tool will only examine GSE emissions if the ULSJ box is selected. The user selects the fuel being used in the aircraft and GSE by selecting the appropriate boxes underneath "Aircraft Fuel" and "Ground Support Equipment Fuel." If the user had previously selected "Jet A," then the AFIT tool would automatically select "ULS Diesel" for the "Ground Support Equipment Fuel," and the "Alternative" option would not be available.

Fuel Economics

The "Fuel Economics" tab, Figure 2, captures all the costs associated with production and transportation of the alternative fuel from its production source to the wing of the plane and GSE. Production cost is entered as the purchase price of the alternative fuel from the production facility.

Fuel delivery is broken down into "off airport" and "on airport" components. Off airport includes shipment from production to the airport fence line. On airport captures costs from the fence to the aircraft and GSE. These include airport costs such as storage, flowage, volume throughput charges, and so on. Delivery is typically by pipeline, rail car, barge, or truck. Selecting one of these modes inserts a default cost, or the user can supply the user's own by typing it into the field. The default costs are truck, \$0.35; barge, \$0.05; dedicated pipeline, \$0.02; and rail, \$0.10 (all per gallon). There is no default cost for "other" in this version of AFIT. To enter any of the above default costs, select a mode of transportation and then click default at the bottom of the tab, and the cost will be entered in the field. If an airport operator is buying an alternative fuel "at the fence," then by entering zeros for off-airport costs, AFIT will reflect the price at the airport.

The user enters values appropriate to the airport in the analysis, or typical average cost-per-gallon estimates can be input by clicking the default button in the bottom right corner.

These various off-airport and on-airport handling costs are added to the production cost, and new totals are calculated by AFIT and displayed at the top of the tab in the section called "Fuel Cost." The user-entered Jet A and diesel fuel prices are shown, as is the estimated alternative fuel price based on user inputs lower down on the tab. Annual total fuel cost estimates are shown, as is the cost difference between Jet A and diesel and the alternative fuel.

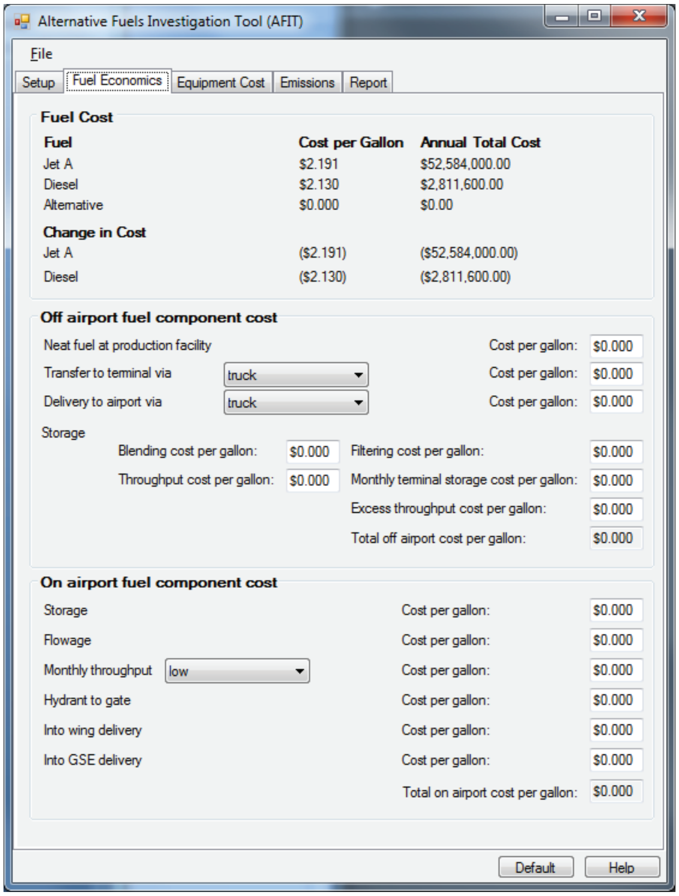

Figure 2. "Fuel Economics" tab.

Equipment Cost

The "Equipment Cost" tab, Figure 3, captures the costs associated with changes to the aircraft and GSE that accompany a change in fuel. It also captures the avoided fueling infrastructure costs associated with using the alternative fuel in both aircraft and diesel engine GSE and the decommissioning costs of taking existing diesel fueling equipment out of service.

AFIT assumes that the alternative fuel has been certified for aircraft use. As a result there are no equipment costs associated with aircraft, which should be a valid assumption for 50-50 alternative fuel blends. Higher alternative fuel concentrations could require replacement of aircraft seals due to reduced fuel aromatic content or a decrease in required maintenance due to reduced sulfur content.

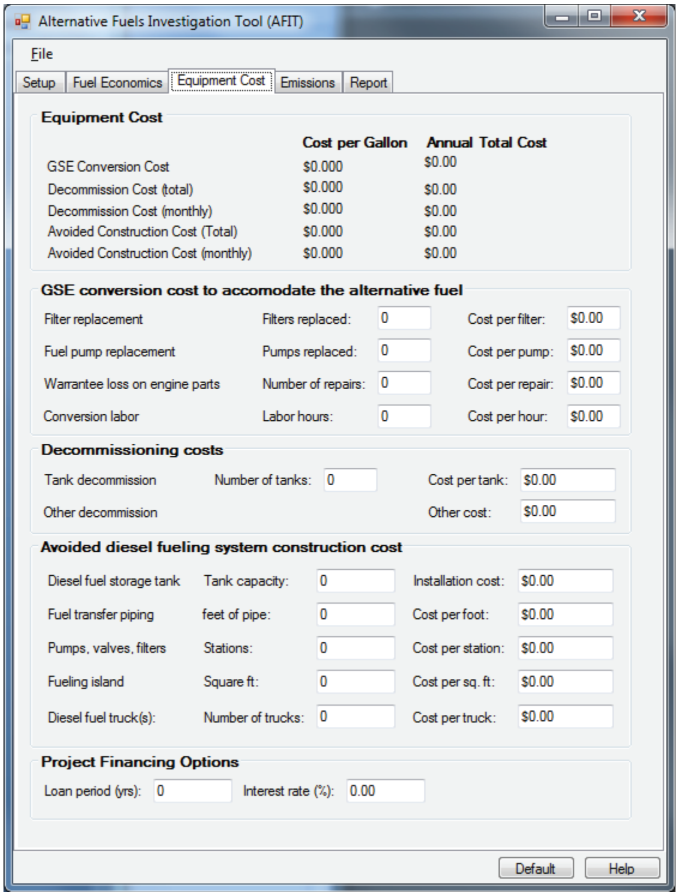

Figure 3. "Equipment Cost" tab.

The "Equipment Cost" tab captures the costs associated with upgrades and replacements necessary on certain GSE. Rubber seals, fuel filters, fuel pumps, possible warrantee losses, and the labor associated with replacements are captured here. Quantities and costs of each and the labor required to perform installations and other maintenance must be estimated.

While GSE conversion costs add to the price of the alternative fuel, in the case of a new airfield or expansion of existing facilities, a single fuel source for both aircraft and GSE allows an airport to avoid construction cost for diesel fueling facilities. If the user selected the "New Construction" box on the "Setup" tab, these fields will be active for data entry.

Typical diesel fuel delivery infrastructure, equipment, and fabrication costs are represented in this section of the tab. If the user has not checked the "New Construction" box on the "Setup" page, these fields will not be accessible. The user will input construction cost estimates to compute avoided diesel fueling equipment and construction costs. Cost totals are represented at the top of the tab in both total single year expensed cost and monthly costs if the project is financed over several years and a period of payments is selected by the user.

Emissions

The "Emissions" tab, Figure 4, captures the changes in emissions that may result if the airport switches to an alternative jet fuel. It is also where the user must have access to EDMS reports and software.

The user must locate an existing EDMS study to form the basis for the baseline in the AFIT study. It is important to note that the emissions displayed are adjusted for this analysis and are not intended to match the EDMS results.

To determine the life-cycle emissions of a fuel, a specific feedstock and production pathway must be selected from the list of potential alternative jet fuels using the pull-down menu. The life-cycle emissions are provided in the form of ranges to give the user a sense of the emissions that may result from each alternative fuel. The user can also input custom emission factors for another fuel (if it is not on the list) by selecting the "User-defined emission factors" radio button. Additional details on life-cycle emissions can be found in Appendix D.

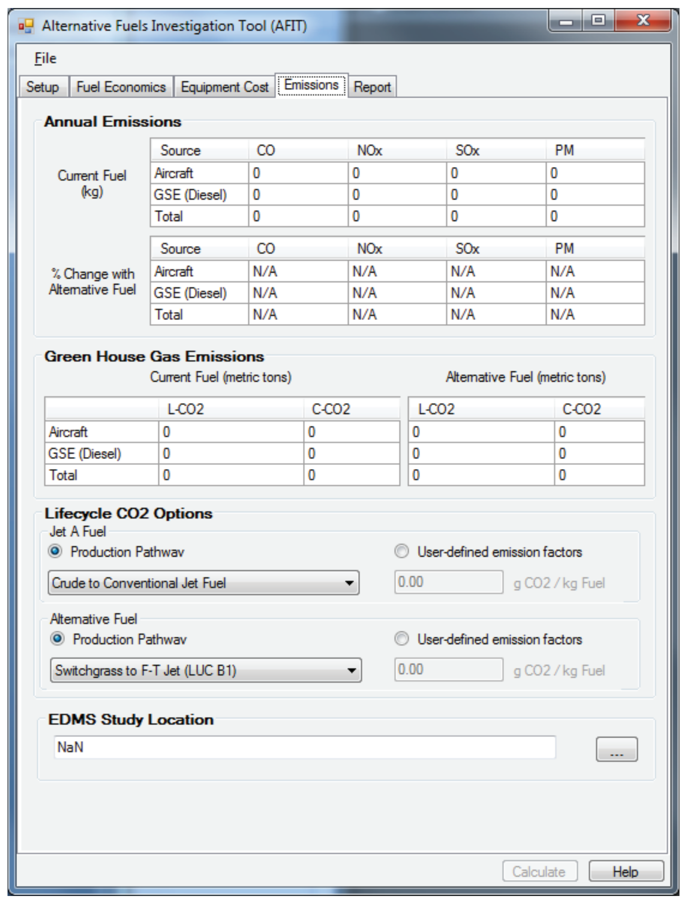

Figure 4. "Emissions" tab.

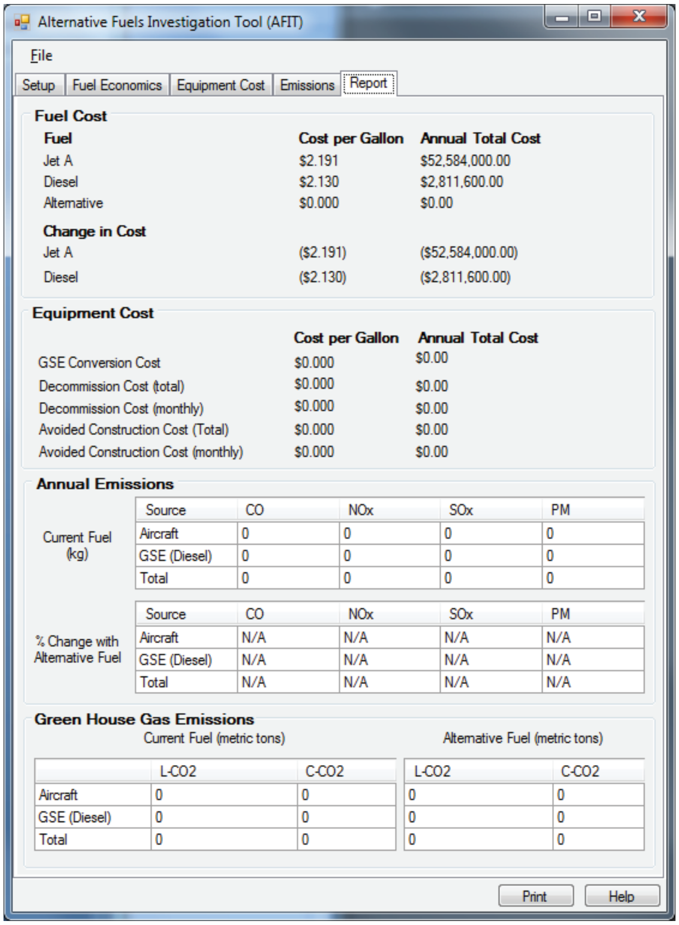

Figure 5. "Report" tab.

Report

The "Report" tab, Figure 5, compiles the information input by the user, calculated by AFIT, and derived from EDMS to represent, on a single page, the comparison in costs to deliver an alternative drop-in fuel and the reduced emissions that result.

The user can view the summary cost and emissions data for comparison. This tab also permits the user to print reports to capture cost and emissions estimates for comparison.

CHAPTER 3

Evaluating the Results of an Alternative Jet Fuel Cost–Benefit Analysis

3.1 Emissions

AFIT reports out two categories of pollutants on the "Emissions" tab—criteria pollutants and life-cycle greenhouse gases. The emission changes are compared to Jet A in the aircraft and ULS diesel in the GSE.

Carbon monoxide (CO), nitrogen oxides (NO_x), SO_x, and PM with a diameter of 2.5 micrometers or less ($PM_{2.5}$) are criteria pollutants.[1] These pollutants are broken out by source (aircraft or GSE) and fuel (current or alternative) in the "Emissions" tab. The emissions reflected in the "Current Fuel" table have been adjusted from the EDMS run used as an input file for this analysis. The emissions in the "Alternative Fuel" table reflect the computed emissions from the specific fuel blend entered in the "Setup" tab. If the alternative fuel is not used in GSE or aircraft, the emissions will be unchanged from the baseline (current fuel) emissions. The emission values shown for alternative fuels include the change in fuel use that results from an alternative fuel.

The GHG emissions from aircraft and GSE are reported in two separate categories—combustion CO_2 and life-cycle CO_2e (LC CO_2e). Combustion CO_2 changes by fuel type based on the amount of fuel consumed and the relative carbon content of the fuel. This is the amount of CO_2 emitted due to combustion and is typically the value included in an airport's GHG inventory or carbon footprint. LC CO_2e reflects the GHG emissions (carbon dioxide, nitrous oxide, and methane) created during the production of the fuel as well as the combustion CO_2. This illustrates the total GHG impact from using a particular fuel. The changes in life-cycle emissions will, in general, dwarf any changes in combustion emissions, and these changes are due to the details of fuel production, as is discussed briefly in Appendix D.

[1]The AFIT tool was based on the best data that was available at the time of AFIT publication. However, additional testing of the emissions from alternative fuel combustion was ongoing at that time, and additional work was being devoted to estimating life-cycle greenhouse gas emissions.

3.2 Costs

Specific costs associated with the introduction of an alternative fuel depend on individual airport considerations. AFIT was developed to accommodate most possibilities. AFIT is designed to collect standard fuel-related costs such as

- The fuel—the purchase of the product itself, likely from the production facility;
- Transportation to the airport—via pipeline, rail, barge, truck;
- Storage—in nearby facilities such as a fuel terminal and on the airport property;
- Fuel handling—blending, filtering and other fees; and
- On- and off-airport costs—reflecting inside- and outside-airport perimeter differences.

Annual and monthly consumption amounts for both Jet A and diesel fuels are also relevant since fuel suppliers modify fee structures depending on volume and infrastructure cost scale with volume-related measures (e.g., a 2-million-gallon storage tank costs more to build and maintain than a 1-million-gallon tank). This also enables conversion of raw costs to cost per gallon for comparison to Jet A and diesel.

Upgrades to GSE seals, gaskets, filters, pumps, and so on and the labor to perform installation are collected. Some discretion should be used with respect to equipment upgrades since some portion may occur during normal maintenance intervals. There is also the possibility that certain warrantees may be voided, and consideration for these costs must be made. Based on conversations with experts in the field, there appears to be a risk that if you put jet fuel into a diesel engine without first getting the manufacturer's approval, you then run the risk of voiding your warranty. Simply put, jet fuel certification covers jet engines. It does not automatically cover diesel engines. While there may not be an issue with the GSE engine warranty, this represents a potential cost that has not yet been completely resolved. By definition, a “drop-in” fuel is fully compatible with aircraft engine specifications, and it is assumed that no aircraft-related costs are incurred. It is anticipated that GSE upgrade costs will be expensed in the year in which they are incurred, for accounting purposes; however, a fundamental determination must be made regarding capital costs or the avoidance of them. AFIT is able to collect cost estimates in cases where the fuel will be dispensed through existing equipment and infrastructure at the airport and in situations where substantial new infrastructure development will be undertaken, such as with a new airport or a major expansion of the current facility. The reason this is important is that an alternative fuel compatible with both aircraft and GSE would reduce costs since two fueling systems would be replaced by a single system. AFIT is constructed to accommodate both circumstances and converts monthly capital financing charge estimates into a per-gallon fuel cost estimate.

AFIT converts and sums all costs into a per-gallon estimate for comparison with existing Jet A and diesel usage. Monthly and annual cost data are provided to assist with tracking and accounting. The analyst can input various costs and quantities of equipment affected, and AFIT updates the cost-per-gallon estimates, which can be compared to existing fuel costs.

AFIT intentionally does not provide a cost and benefit calculation as that is the purview of the analyst. It is designed to assist with categories of likely costs and also provides default estimates should the user not have specific data pertinent to the user’s facility. These estimates were collected from a range of sources and represent an approximation for use only when airport-specific values are not available.

3.3 Health Benefits from Improved Air Quality

Atmospheric $PM_{2.5}$, a criteria air pollutant that has been linked to respiratory illnesses and premature mortality, results from primary PM emissions as well as emissions of NO_x, SO_x, and unburned hydrocarbons. These latter pollutants, which are referred to as secondary PM precursors, are transformed in the atmosphere into aerosol PM, also referred to as secondary PM. Secondary PM is significantly more prevalent on a mass basis than primary PM. Emissions from aircraft, GSE, and other equipment and vehicles around an airport contribute to both primary and secondary atmospheric PM. The alternative fuels considered in AFIT have the potential to reduce $PM_{2.5}$ through a reduction in both primary PM and SO_x, which yields health benefits. The report includes an analysis of the impact of using both ULS and SPK blends on the air quality in the region surrounding Atlanta Hartsfield International Airport.

3.4 Making the Decision to Use an Alternative Jet Fuel

The analysis conducted by AFIT is meant to inform the user about the potential economic costs and changes in emissions that could result from switching to an alternative fuel. The results are best viewed as a screening assessment of whether an airport should consider an alternative jet fuel for use in aircraft and/or diesel-engine GSE. If the emission reduction benefits identified by AFIT are significant enough for the airport to seriously consider using an alternative fuel, a more-detailed engineering study will be required to fully quantify all costs.

APPENDIX A

Cost–Benefit Computations

AFIT is designed to assist fuel analysts in determining costs associated with introducing an alternative fuel and benefits as measured by reduced emissions. It is not a cost–benefit tool offering the analyst the decision to use an alternative fuel or not. To this end, AFIT is structured around two cost and one benefit computation pages or tabs.

Fuel Economics Costs

Fuel economics costs consist of off-airport (costs outside the airport perimeter fence) and on-airport costs (costs incurred inside the perimeter fence). These include transportation and storage and storage-related costs (filtering, blending) and, in the case of off airport, the cost of the alternative fuel. Costs are entered as a per-gallon charge, and AFIT sums them, using monthly gallons-consumed information, into a total monthly cost estimate for each cost component.

The calculations are simple addition, multiplication, and division operations producing per-gallon and total costs in dollars for user reference to current monthly costs.

Equipment Costs

There are three groupings on this tab.

1. GSE conversion costs to ready the equipment for the alternative fuel;
2. Decommissioning costs to remove the diesel-related tanks, piping, and equipment; and
3. Avoided construction costs of a new diesel facility in cases where significant expansion or new facilities associated with airport expansion required them.

All costs should be entered per unit. For example, if the GSE fleet requires 200 filters to be replaced, then enter 200 and the cost per filter, for example $10.00, and AFIT will calculate the cost to convert into the cost per gallon and the annual cost of replacement. A simple financing cost calculation is also supplied for the avoided diesel fueling system construction costs since these costs are likely to be significant and financed over time.

Emissions

Baseline emissions are imported from an EDMS study. AFIT calculates the new inventories based on the fuel selected and the equipment at the airport. Differences are displayed on the emissions and report tabs for the analyst to use for further consideration in whether to adopt an alternative fuel.

APPENDIX B

Sources of Data

Some data needed for the fuel comparisons can be found easily. Other information, such as transportation costs (pipeline, truck, barge, rail, etc.) and storage and blending fees depend on the facility and businesses involved. Fuel information is provided below. The AFIT software provides the typical cost range for the various handling fees.

Fuel

Gasoline and Diesel
EIA gasoline and diesel prices:
http://tonto.eia.doe.gov/dnav/pet/pet_pri_gnd_dcus_nus_w.htm
U.S. Gulf Coast No. 2 Diesel Low Sulfur Spot Price FOB (cents per gallon)
http://tonto.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=rdlusg&f=d
IATA Jet Fuel Price Monitor
http://www.iata.org/whatwedo/economics/fuel_monitor/index.htm
ATA Jet Fuel Price Statistics
http://www.airlines.org/Energy/FuelCost/Pages/MonthlyJetFuelCostandConsumptionReport.aspx

Alternative Fuel Price Estimates at the Producer

Many reports (e.g., Hileman et al., 2009) provide estimates of the economic costs of producing fuel, but these values are in terms of the fuel producer. This should not be confused with the price that would be paid by a fuel consumer. The price paid by a consumer will be set by the prevailing market price for conventional jet fuel. Assuming that the fuel producer can create its alternative jet fuel at a cost that is less than the prevailing price of conventional jet fuel, it will sell it at the market price of conventional jet fuel to maximize profits. However, if the fuel producer and fuel buyer go into a long-term contract, then the fuel producer may sell its product at a discount to conventional jet fuel. Because of this, AFIT has a default assumption that the price of the alternative fuel is assumed to be 90% of conventional jet fuel.

Transportation and Storage Costs

These costs are not collected and posted conveniently on any single website. The cost ranges provided in AFIT were collected by reviewing financial filings, regulatory requirements, and other legal and non-legal documents and sources. Pipeline, barge, truck, and rail costs vary widely depending on a multitude of factors. The Energy Information Association (EIA) is a large repository of useful information and can be found at http://www.eia.doe.gov/.

New Diesel Fueling Station Costs

Construction costs vary depending on region, project type, preexisting arrangements, and so on, but the RSMeans Building Construction Cost Data manual is an excellent source for the latest industry standards. The 2008 edition was used for this version of the handbook. A 2010 version of the manual is now available.

Equipment Costs

GSE equipment replacement costs vary widely depending on the equipment on site, its age and condition, onsite inventory, mechanical skill level of employees, and other factors. Fleet and equipment managers currently maintaining the equipment will likely be able to find the best cost data with their current suppliers.

APPENDIX C

Glossary, Acronyms, and Abbreviations*

ACRP	Airport Cooperative Research Program
AFIT	Alternative Fuels Investigation Tool
ASTM	the American Society of Testing and Materials
CAAFI	the Commercial Aviation Alternative Fuels Initiative
CO	carbon monoxide
CO_2	carbon dioxide
Drop In	a fuel that can be mixed in with existing fuels in the system with no deleterious effect
EDMS	Emissions and Dispersion Modeling System
EPA	the Environmental Protection Agency
FAA	Federal Aviation Administration
GHG	greenhouse gas
GSE	ground support equipment
Jet A	conventional jet fuel
LC	life cycle
LC CO_2e	life-cycle CO_2 emissions
NO_x	nitrogen oxides
PM	particulate matter
SO_x	sulfur oxide
SPK	synthetic paraffinic kerosene
ULSJ	ultralow sulfur jet fuel
USAF	United States Air Force

*Definitions of key terms necessary to using AFIT; a more extensive glossary is included in the report.

APPENDIX D

Life-Cycle Greenhouse Gas Emissions

To accurately assess the impact of fuel combustion on global climate change, one must consider the full fuel life cycle, from feedstock extraction through fuel combustion. If one only considers combustion, then for the fuels considered here (conventional jet fuel, SPK, and ULSJ fuel) the emissions of an alternative fuel will vary by less than 4%, and this is true regardless of the feedstock used to create the fuel (petroleum, natural gas, coal, or biomass) or how the fuel is processed. It is only from a life-cycle standpoint that one can see that biofuels offer the potential to reduce aviation's impact on global climate change. Biofuels can lessen aviation's production of greenhouse gases because the biofuel feedstock was created by photosynthetic reaction of water with carbon dioxide; thus, if atmospheric carbon dioxide was used to grow the biomass, then the combustion of the biofuel results in the carbon dioxide being returned to the atmosphere from which it came and there is zero net emissions of carbon dioxide into the atmosphere from fuel combustion. This is not true for fossil fuel combustion, where the fuel feedstock contains carbon that has been sequestered from the atmosphere for millions of years. Further background information and guidance on creating a life-cycle GHG inventory can be found within AFLCAWG (2009).

The life-cycle GHG emissions from a variety of potential alternative jet fuels are plotted in Figure 6; these data are from the analysis of Stratton et al. (2010). These results include an assessment on the anticipated impact of variations in feedstock properties and process efficiencies on life-cycle GHG emissions as well as an analysis of the impacts of land-use changes. Five life-cycle steps were considered: feedstock recovery (e.g., mining, farming, pumping), feedstock transportation, feedstock processing (e.g., gasification, F-T synthesis, refining), transportation (of finished fuel), and fuel combustion. Because of the increased energy intensity of feedstock extraction, unconventional petroleum fuels (oil sands and oil shale) have increased life-cycle carbon dioxide emissions relative to fuels created from crude oil. A ULS fuel has a slight increase in life-cycle carbon dioxide emissions because of the additional processing (i.e., refining) that is necessary to desulfurize the fuel. To achieve emissions comparable to conventional fuels, F-T fuels must either use carbon capture and sequestration (CCS) or incorporate biomass. Without CCS, F-T fuels from coal will have roughly twice the life-cycle carbon dioxide emissions. Hydroprocessed renewable jet (HRJ) fuels have emissions that are highly dependent on the feedstock that is being used, with emissions from either land-use change dominating (Table 1).

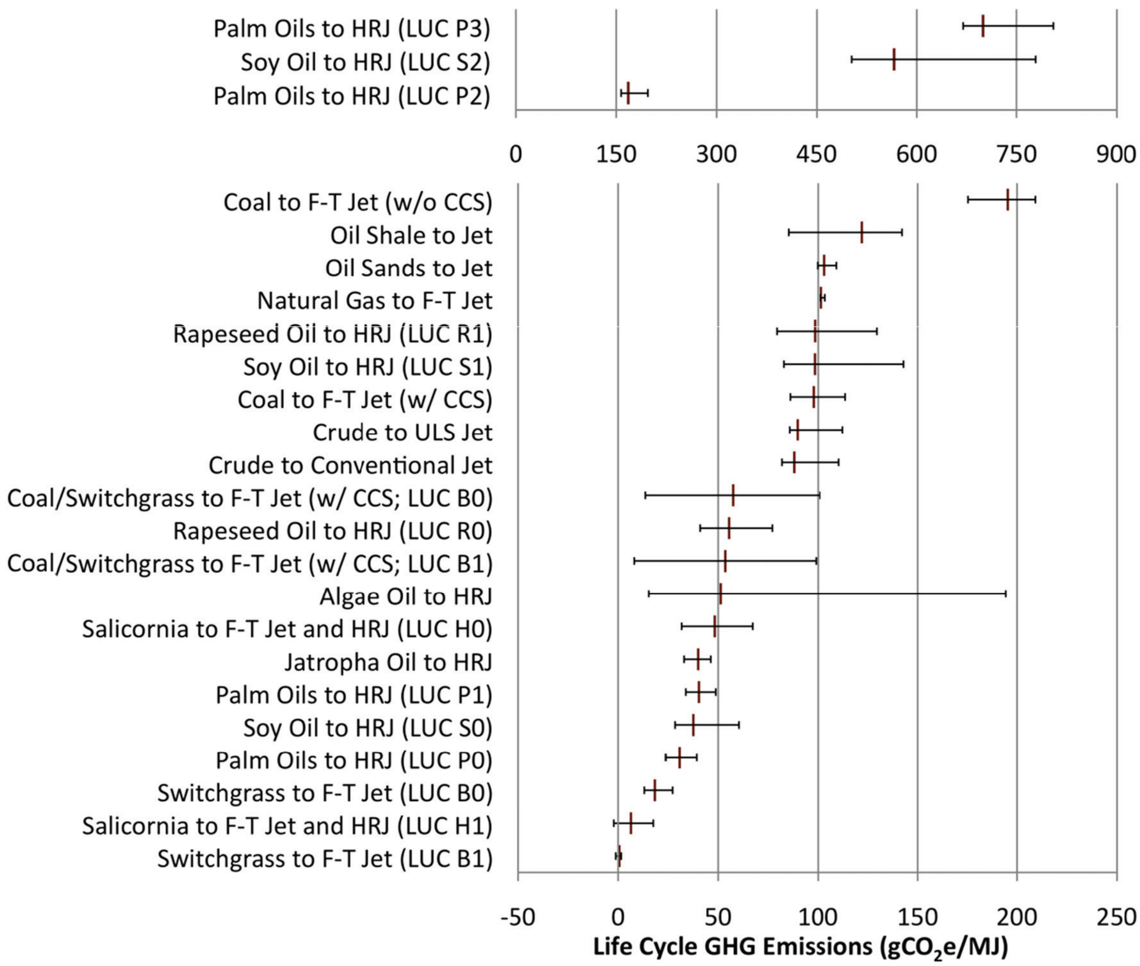

Figure 6. Life-cycle greenhouse gas emissions from a variety of potential alternative fuel pathways that could result in SPK, ULS, or conventional fuels [from Stratton et al. (2010) with permission].

Table 1. Land-use change scenarios explored for HRJ pathways [from Stratton et al. (2010) with permission].

Land-Use Change	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Switchgrass	None	Carbon depleted soils converted to switchgrass cultivation	n/a	n/a
Soy oil	None	Grassland conversion to soybean field	Tropical rainforest conversion to soybean field	n/a
Palm oil	None	Logged-over forest conversion to palm plantation field	Tropical rainforest conversion to palm plantation field	Peatland rainforest conversion to palm plantation field
Rapeseed oil	None	Set-aside land converted to rapeseed cultivation	n/a	n/a
Salicornia	None	Desert land converted to *Salicornia* cultivation field	n/a	n/a

References

AFLCAWG (Aviation Fuel Life Cycle Assessment Working Group). *Framework and Guidance for Estimating Greenhouse Gas Footprints of Aviation Fuels.* Air Force Research Laboratory Technical Report, AFRL-RZ-WP-TR-2009-2206, April 2009. http://web.mit.edu/aeroastro/partner/reports/proj28/greenhs-gas-ftprnts.pdf. Accessed March 31, 2010.

Hileman, J., D. Ortiz, J. Bartis, H. M. Wong, P. Donohoo, M. Weiss, and I. Waitz. *Near-Term Feasibility of Alternative Jet Fuels.* Jointly published by the RAND Corporation (Report No. TR-554-FAA) and the Partnership for AiR Transportation Noise and Emissions Reduction (Report No. PARTNER-COE-2009-001), 2009. http://web.mit.edu/aeroastro/partner/reports/proj17/altfuelfeasrpt.pdf. Accessed March 31, 2010.

Stratton, R., H. M., Wong, J. Hileman. *PARTNER Project 28 Report: Life Cycle Greenhouse Gas Emissions from Alternative Jet Fuels, Version 1.0.* Partnership for AiR Transportation Noise and Emissions Reduction Report No. PARTNER-COE-2010-001, 2010. http://web.mit.edu/aeroastro/partner/reports/proj28/. Accessed March 31, 2010.